What is claimed is:

1. A process for treating a halogen-containing gas, comprising:

providing a treatment gas that includes at least one halogen-containing gas;

mixing at least one gaseous reducing agent with the treatment gas resulting in a feed gas mixture; and

generating a non-thermal plasma in the feed gas mixture in the presence of a liquid to reduce the halogen-containing gas.

2. A process according to claim 1, wherein the treatment gas comprises a mixture of about 0.000001 to about 25 volume % halogen-containing gas and at least one non-halogenated gas diluent.

3. A process according to claim 1, wherein the temperature of the feed gas mixture does not exceed about 100°C during generation of the non-thermal plasma.

4. A process according to claim 1, wherein the liquid comprises water.

5. A process according to claim 1, wherein the reducing agent is selected from hydrogen, hydrocarbon, ammonia, hydrazine, hydride, amine, and amide.

6. A process according to claim 1, wherein the liquid absorbs the heat produced from the reduction of the halogen-containing gas.

7. A process according to claim 1, wherein the non-thermal plasma comprises a silent discharge plasma.

8. A process according to claim 1, wherein the liquid has a boiling point of less than about 150°C and a heat of vaporization of at least about 35 kJ/mole.

9. A process for treating a halogen-containing gas, comprising:

introducing a halogen-containing gas and a reducing agent into a chamber;

introducing a liquid into the chamber;

generating a non-thermal plasma in the chamber to reduce the halogen-containing gas; and

exhausting the resulting reduction product from the chamber.

10. A process according to claim 9, wherein the liquid flows through the chamber during generation of the non-thermal plasma.

11. A process according to claim 10, wherein the halogen-containing gas and the reducing agent flow through the chamber in a first current direction and the liquid flows through the chamber in a second current direction that is substantially co-current with the first current direction.

12. A process according to claim 10, wherein the halogen-containing gas and the reducing agent flow through the chamber in a first current direction and the liquid flows through the chamber in a second current direction that is substantially counter-current with the first current direction.

13. A process according to claim 9, wherein the chamber contains at least one electrode and the liquid flows as a film over at least a portion of the electrode.

14. A process according to claim 13, wherein the reducing agent is a gas that is introduced into the chamber by bubbling the gaseous reducing agent through the liquid film.

15. A process according to claim 9, wherein the liquid comprises water.

16. A process according to claim 13, wherein the non-thermal plasma is generated at or near a surface of the liquid film.

17. A process according to claim 9, wherein the reducing agent is selected from hydrogen, hydrocarbon, ammonia, hydrazine, hydride, amine, and amide.

18. A process according to claim 9, wherein the liquid absorbs the heat produced from the reduction of the halogen-containing gas.

19. A process according to claim 9, wherein the non-thermal plasma comprises a silent discharge plasma.

20. A process according to claim 9, wherein the temperature of the halogen-containing gas, the reducing agent, and the resulting reaction product do not exceed about 100°C during generation of the non-thermal plasma.

21. A process according to claim 9, wherein the liquid has a boiling point of less than about 150°C and a heat of vaporization of at least about 35 kJ/mole.

22. A process for treating a halogen-containing gas, comprising:

providing a treatment gas that includes at least one halogen-containing gas;

mixing at least one gaseous reducing agent with the treatment gas resulting in a feed gas mixture;

generating a non-thermal plasma in the feed gas mixture in the presence of liquid water to produce a reaction product mixture that includes a water-soluble halogen-containing reduction product; and

separating the water-soluble halogen-containing reduction product from the reaction product mixture.

23. A process according to claim 22, wherein the separating step comprises aqueous scrubbing.

24. A process for treating a halogen-containing gas, comprising:

providing a treatment gas that includes at least one halogen-containing gas;

mixing at least one gaseous reducing agent with the treatment gas resulting in a feed gas mixture;

generating a non-thermal plasma in the feed gas mixture in the presence of liquid water to reduce the halogen-containing gas and produce a water-soluble halogen-containing reduction product; and

dissolving at least a portion of the amount of the water-soluble halogen-containing reduction product into the liquid water.

25. A process for treating a halogen-containing gas, comprising:

providing a treatment gas that includes at least one halogen-containing gas;

mixing at least one gaseous reducing agent with the treatment gas resulting in a feed gas mixture; and

generating a plasma in the feed gas mixture in the presence of liquid water to reduce the halogen-containing gas.

26. A process according to claim 25, wherein the treatment gas comprises a mixture of about 0.000001 to about 25 volume % halogen-containing gas and at least one non-halogenated gas diluent.

27. A process according to claim 25, wherein the temperature of the feed gas mixture does not exceed about 100°C during generation of the plasma.

28. A process according to claim 25, wherein the reducing agent is selected from hydrogen, hydrocarbon, ammonia, hydrazine, hydride, amine, and amide.

29. A process according to claim 25, wherein the liquid water absorbs the heat produced from the reduction of the halogen-containing gas.

30. A process for treating fluorine gas, comprising:

providing a treatment gas that includes fluorine gas;

mixing at least one reducing agent with the treatment gas resulting in a feed gas mixture; and

generating a non-thermal plasma in the feed gas mixture to convert the fluorine gas to hydrogen fluoride gas.

31. A process according to claim 30, wherein the treatment gas further comprises at least one non-halogenated gas.

32. A process according to claim 31, wherein the non-halogenated gas comprises nitrogen.

33. A process according to claim 30, wherein the treatment gas comprises about 0.000001 to about 25 volume % fluorine gas.

34. A process according to claim 30, wherein the reducing agent is selected from hydrogen, hydrocarbon, ammonia, hydrazine, hydride, amine, and amide.

35. A process according to claim 30, wherein the reducing agent comprises hydrogen.

36. A process according to claim 35, wherein the amount of hydrogen mixed with the fluorine gas is about 0.5:1 to about 4:1 H_2:F_2 atom molar ratio.

37. A process according to claim 30, further comprising dissolving the hydrogen fluoride in water.

38. A process for treating fluorine gas, comprising:

providing a treatment gas that includes fluorine gas;

mixing at least one gaseous reducing agent with the treatment gas resulting in a feed gas mixture; and

generating a non-thermal plasma in the feed gas mixture in the presence of a liquid to convert the fluorine gas to hydrogen fluoride gas.

39. A process according to claim 38, wherein the treatment gas further comprises at least one non-halogenated gas.

40. A process according to claim 39, wherein the non-halogenated gas comprises nitrogen.

41. A process according to claim 38, wherein the treatment gas comprises about 0.000001 to about 25 volume % fluorine gas.

42. A process according to claim 38, wherein the reducing agent is selected from hydrogen, hydrocarbon, ammonia, hydrazine, hydride, amine, and amide.

43. A process according to claim 38, wherein the reducing agent comprises hydrogen.

44. A process according to claim 43, wherein the amount of hydrogen mixed with the fluorine gas is about 0.5:1 to about 4:1 H_2:F_2 atom molar ratio.

45. A process according to claim 38, further comprising dissolving the hydrogen fluoride in water.

46. A process according to claim 38, wherein the liquid comprises water.

47. A process according to claim 44, wherein the liquid comprises water.

48. A process according to claim 38, wherein the liquid has a boiling point of less than about 150°C and a heat of vaporization of at least about 35 kJ/mole.

49. A process for treating fluorine gas, comprising:

providing a treatment gas that includes fluorine gas;

mixing at least one hydrogen-donating gas with the treatment gas resulting in a feed gas mixture; and

generating a non-thermal plasma in the feed gas mixture in the presence of water to convert the fluorine gas to hydrogen fluoride gas.

50. A process for treating fluorine gas, comprising:

introducing fluorine gas into a chamber;

introducing a reducing agent into the chamber;

generating a non-thermal plasma in a mixture that includes the fluorine gas and the reducing agent contained in the chamber to reduce the fluorine gas to hydrogen fluoride; and

exhausting the hydrogen fluoride from the chamber.

51. A process according to claim 50, further comprising introducing a liquid into the chamber.

52. A process according to claim 51, wherein the chamber contains at least one electrode and the liquid flows as a film over at least a portion of the electrode.

53. A process according to claim 52, wherein the reducing agent is a gas that is introduced into the chamber by bubbling the gaseous reducing agent through the liquid film.

54. A process according to claim 51, wherein the liquid comprises water.

55. A process according to claim 50, wherein the fluorine gas is included in a mixture with nitrogen.

56. A process according to claim 50, wherein the reducing agent is selected from hydrogen, hydrocarbon, ammonia, hydrazine, hydride, amine, and amide.

57. A process for treating a halogen-containing gas, comprising:

providing a chamber defining at least one gas inlet for receiving a feed gas mixture that includes a halogen-containing gas and a gaseous reducing agent, and at least one water inlet for receiving liquid water;

providing at least one first electrode disposed within the chamber;

providing at least one second electrode disposed within the chamber;

flowing the liquid water over at least a portion of the first electrode; and

applying electric potential to the first and second electrodes so as to generate a plasma in the feed gas mixture and reduce the halogen-containing gas.

58. A process according to claim 57, wherein a dielectric barrier is disposed on a surface of at least one of the first or second electrodes and the generated plasma comprises a non-thermal plasma.

59. A process according to claim 57, further comprising providing gas/liquid scrubbing packing material within the chamber.

60. A process for treating a halogen-containing gas, comprising:

providing a chamber defining at least one first gas inlet for receiving a halogen-containing gas, and at least one water inlet for receiving liquid water;

providing at least one first electrode disposed within the chamber and defining at least one second gas inlet for receiving a gaseous reducing agent;

providing at least one second electrode disposed within the chamber;

flowing the liquid water over at least a portion of the first electrode;

introducing the gaseous reducing agent through the liquid water and into the chamber so as to mix with the halogen-containing gas and form a feed gas mixture; and

applying electric potential to the first and second electrodes so as to generate a plasma in the feed gas mixture and reduce the halogen-containing gas.

61. A process according to claim 60, wherein a dielectric barrier is disposed on a surface of at least one of the first or second electrodes and the generated plasma comprises a non-thermal plasma.

62. A process according to claim 60, further comprising providing gas/liquid scrubbing packing material within the chamber.

63. A plasma reactor apparatus, comprising:

a chamber defining at least one first gas inlet for receiving a first gas, and at least one water inlet for receiving liquid water;

at least one first electrode disposed within the chamber and defining a first surface that is in fluid communication with the water inlet for receiving liquid water, and at least one second gas inlet for receiving a second gas; and

at least one second electrode disposed within the chamber and opposing the first surface of the first electrode;

wherein a dielectric barrier is disposed on at least one of the first surface of the first electrode or a surface of the second electrode.

64. An apparatus according to claim 63, wherein the first electrode defines a plurality of second gas inlets.

65. An apparatus according to claim 63, further comprising gas/liquid scrubbing packing material disposed within the chamber.

66. An apparatus according to claim 63, further comprising an electrochemical cell that is in fluid communication with the second gas inlet.

67. An apparatus according to claim 63, wherein the first electrode defines a cylinder shape and is immersed in the liquid water.

68. An apparatus according to claim 63, comprising a plurality of spaced-apart first electrodes and a plurality of second gas inlets defined by the spaces between the spaced-apart first electrodes.

69. A system for treating a halogen-containing gas, comprising:

a plasma reactor for reducing halogen-containing gas;

a halogen-containing gas source in fluid communication with the plasma reactor;

a reducing agent source in fluid communication with the plasma reactor; and

a liquid source in fluid communication with the plasma reactor.

70. A system for treating fluorine gas, comprising:

a non-thermal plasma reactor for converting fluorine gas to hydrogen fluoride;

a fluorine gas source in fluid communication with the non-thermal plasma reactor;

a hydrogen gas source in fluid communication with the non-thermal plasma reactor; and

a liquid water source in fluid communication with the non-thermal plasma reactor.

71. A system according to claim 70, wherein the fluorine gas source comprises an effluent gas from a manufacturing process.

72. A system according to claim 70, further comprising a gas/liquid scrubber unit in fluid communication with a hydrogen fluoride exhaust outlet from the non-thermal plasma reactor.

73. A system according to claim 70, further comprising a water recycling conduit that is in fluid communication with the non-thermal plasma reactor and the liquid water source.

74. A plasma reactor apparatus, comprising:

a chamber;

means for generating a non-thermal plasma in the chamber that includes at least one electrode;

means for introducing a liquid over at least a portion of the electrode; and

means for bubbling a first gas through the liquid for reaction in the non-thermal plasma.

75. An apparatus according to claim 74, further comprising means for introducing a second gas into the chamber.

76. An apparatus according to claim 74, wherein the electrode defines a boundary along which the liquid can flow.

77. An apparatus according to claim 74, further comprising means for introducing the first gas through the electrode and into the liquid.

78. A plasma reactor apparatus, comprising:

a chamber having an interior void;

means for generating a non-thermal plasma in the interior void of the chamber that includes at least one electrode;

means for introducing a liquid over at least a portion of the electrode;

means for introducing a first gas through the liquid and into the interior void of the chamber; and

means for introducing a second gas into the interior of the chamber.

79. An apparatus according to claim 78, further comprising means for electrochemically generating the first gas, wherein the electrochemical means is in fluid communication with the means for introducing the first gas into the interior void of the chamber.